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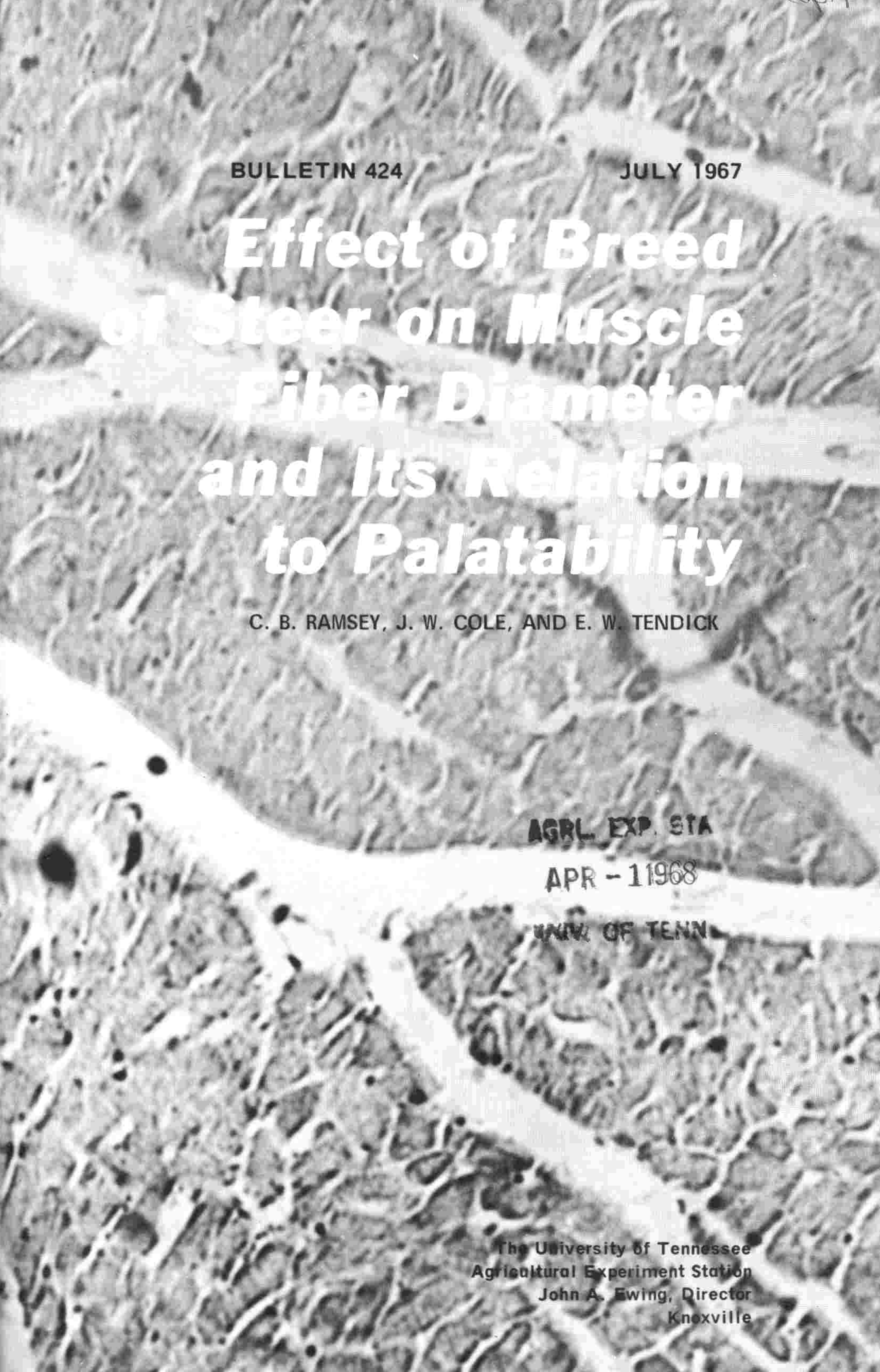

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Effect of Breed of Steer on Muscle Fiber Diameter and Its Relation to Palatability

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Contents

Summary

THE EFFECTS of breed on muscle fiber diameter and the relationships among palatability measures and selected production and carcass traits were studied on 34 steers of five breeds.

Brahman and Charolais steers tended to have larger muscle fiber diameters in the *longissimus dorsi* and *semimembranosus* muscles than Angus, Hereford, or Jersey steers. Tenderness of rib roasts, loin steaks, and round steaks tended to follow the same breed pattern with smaller muscle fibers accompanying greater tenderness.

The percent of wavy muscle fibers was not significantly different among breeds. However, these wavy fibers were much more prevalent in samples of *l. dorsi* taken from the warm animal body on the slaughter floor than in samples of *l. dorsi* taken from the same carcasses chilled 48 hours. Likewise, the average diameter of fibers of samples from the warm body was greater than of samples from the chilled carcass.

Simple correlation coefficients on a within-breed basis showed that few relationships between either fiber diameter or percent of wavy fibers and measures of production, carcass, or palatability traits were statistically significant. Some of the significant relationships were:

> Fiber diameter of the chilled *l. dorsi* samples was negatively related to percent of ether extract of the *l. dorsi* and tenderness and juiciness of loin steaks.
>
> The relation of muscle fiber diameter to tenderness appeared to be independent of fat content of the *l. dorsi*, animal age, and body weight.
>
> The amount of marbling in the *l. dorsi* had little effect on palatability measures.
>
> Percent wavy fibers in the *l. dorsi* samples taken from the warm body and the *semimembranosus* samples were negatively related to muscle tenderness, juiciness, and flavor. However, these relationships were much lower when the chilled *l. dorsi* sample was involved.

Effect of Breed of Steer on Muscle Fiber Diameter And Its Relation To Palatability*

by

C. B. Ramsey, J. W. Cole, and E. W. Tendick**

MUSCLE fiber diameter has been proposed as one of the factors affecting beef palatability. Hammond (1932) concluded that muscle fiber size increased with age, exercise, and nutritional level, and was larger in males than in females. Robertson and Baker (1933) found that muscle fiber diameter was largest in full-fed steers, intermediate in half-fed steers, and smallest in steers fed only roughage. Significant differences between steers and cows were shown by Brady (1937) in diameter of muscle fibers and size of bundles. According to Hiner *et al.* (1953) and Tuma *et al.* (1962), muscle fiber diameter increased as animal age increased. Samples with smaller fibers tended to be more tender. However, Romans *et al.* (1965) studied beef ribs and showed that fiber diameter did not vary consistently with carcass maturity level. Joubert (1956) found a significant difference between Friesians and Shorthorns in muscle fiber diameter.

Since little research has been done on the effect of breed on muscle fiber diameter, this study was designed to determine differences in fiber diameter of muscles from steers varying in type and breed. The relation of fiber diameter and other production and carcass traits to meat palatability also was studied.

Experimental Procedure

DATA WERE collected from 34 steers fed at the Blount Farm of the University of Tennessee. Five breeds were represented by at least four steers each (Table 1). All were in the Types and Breeds study.

*Gratitude is expressed to Dr. Bernadine H. Meyer and her staff of the Food Science and Institution Management Department for conducting the cooking and sensory tests.

**Assistant Professor, Professor, and former Graduate Student, respectively, Animal Husbandry-Veterinary Science Department.

Table 1. Number of steers by breed

Breed	Number of steers
Angus	9
Hereford	5
Charolais	8
Brahman	8
Jersey	4
Total	34

Source of Steers. The Hereford and Angus steers were selected from station and Tennessee breeder herds. Those of Zebu and Charolais breeding were purchased in Florida and Louisiana. Jerseys were obtained from University of Tennessee herds at Lewisburg and Knoxville.

Feeding. All steers were full-fed a high-concentrate ration in lots by breed. Allotment by breed was necessary in order to obtain breed feed consumption data necessary for another study. Uniform feeding and management practices were used as described by Cole *et al.* (1963).

Slaughter. Each steer was slaughtered when it weighed approximately 900 pounds or was 20 months old, whichever occurred first. After a rigid 24-hour preslaughter shrink with access to neither feed nor water, each steer was trucked 10 miles to the University Meat Laboratory for slaughter. Ramsey *et al.* (1965) have described the slaughter procedures.

Sampling. After being stunned and bled, the steer was laid on the floor and a sample of *longissimus dorsi* (*l. dorsi*) muscle was taken from the left side. This 1.5-inch diameter sample was removed from the lateral portion of the muscle, beginning at the anterior edge of the 13th rib and terminating about 3 inches posteriorally. The sample was chilled in a 38°F. cooler for 48 hours. The dehydrated surface was removed from the anterior end, and a ⅜-inch slice was cut and placed in a 10% formalin solution for later determination of muscle fiber diameter.

After the left side of the split carcass was chilled for about 48 hours, the *l. dorsi* from the 12th rib section was sampled. This muscle section was divided into lateral and medial halves. Two ⅜-inch slices were cut from the lateral half and fixed in formalin.

The *semimembranosus* muscle in the 4th ½-inch round steak also was sampled. The sample was taken from the medial and posterior portion of the muscle and placed in formalin.

Fiber Diameter Measurements. Care was taken to ensure that all muscle samples for fiber diameter measurements came from the same location in every animal. A ¼-inch cube was cut from each fixed sample and placed in a Waring Blendor. Enough 10% formalin solution was added to cover the blender blades. A rheostat was used to reduce the blender speed so that the majority of the muscle fibers were teased apart rather than cut. Part of the solution was poured into a petri dish for measuring fiber diameter.

A fixed stage microscope with a 10X objective and a 10X ocular micrometer was used to measure fiber diameter. The ocular micrometer was calibrated with a stage micrometer.

At least 50 fibers were measured from each sample of *l. dorsi* taken during slaughter and of *semimembranosus* taken after the carcass was chilled. At least 100 fibers were measured from each sample of *l. dorsi* from the chilled carcasses. Irregularly-shaped or relatively short fibers were not measured.

The percentage of wavy or kinky fibers was estimated by determining this trait in five optical fields of the microscope and averaging the values.

Physical and Chemical Analyses. The 9-10-11 rib section of the left carcass side was physically separated into muscle, fat, and bone. The *l. dorsi* muscle of this section was excised and its specific gravity determined. It then was blotted dry, ground three times, and sampled. The remainder of the *l. dorsi* was combined with the other muscle and fat from the 9-10-11 rib section, ground 3 times, and sampled. The samples were frozen and stored in a freezer before duplicate analyses for moisture, ether extract, and nitrogen were performed according to A.O.A.C. (1960) procedures.

Palatability Tests. After aging 2 weeks at a cooler temperature of about 38°F., the rib, loin, and round of the right side of each carcass were cut into roasts and steaks for sensory panel evaluation. All cuts were wrapped and frozen. A roast containing ribs 6 and 7 was cut from the anterior end of the wholesale rib. Roasting was done from the frozen state in a Despatch oven at 300°F. to an internal temperature of 158°F.

Twenty-four steaks, 0.7 inch thick, were cut from a section composed of the 10th through 12th rib portion of the wholesale rib and the short loin. The 8th, 16th, and 24th steaks (hereafter called "loin steaks") and the 4th ½-inch round steak were broiled in an electric household-type range to an internal temperature of 158°F.

Both kinds of steaks and the rib roast were scored on a nine-point scale (1 = extremely poor; 9 = excellent) for tenderness, juiciness, and flavor by a six-member, experienced laboratory sensory panel. Only the *l. dorsi* muscle from the rib roasts and loin steaks and the *semimembranosus* muscle from the round steaks were scored.

Three ½-inch cores were taken from each of the three loin steaks, and four ½-inch cores were taken from each of the *semimembranosus*, *semitendinosus*, and *biceps femoris* muscles of the round steaks. Each core was sheared once with a Warner-Bratzler shear machine. Two 1-inch cores were taken from each rib roast and sheared two times to obtain objective estimates of tenderness.

Carcass Measurements. Chilled carcass weight was taken after a 48-hour chill period. Carcass grade and marbling score were determined by a Federal grader. Fat thickness was measured between the 12th and 13th ribs at a point three-fourths the length of the *l. dorsi* from the chine end. Carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone.

Statistical Analyses. Data for muscle fiber and percent wavy fibers were analyzed by the method of least squares. Constants were fitted for breed effects. Duncan's (1955) multiple range test, as extended by Kramer (1957), was used to test the significance of differences between means. Simple correlation coefficients were calculated on a within-breed basis.

Results and Discussion

ALTHOUGH fed and managed alike, the breed groups in this study varied in most production and carcass traits as shown in Table 2. Breed differences in these traits will not

Table 2. Means and standard errors for selected production and carcass traits by breed

	Breed									
	Angus		Hereford		Charolais		Brahman		Jersey	
Trait	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Days on feed	207	19	270	27	284	12	372	19	382	25
Average daily gain, lb.	2.09	0.12	2.01	0.13	1.73	0.07	1.69	0.04	1.90	0.13
Age at slaughter, days	448	14	431	16	472	9	511	20	496	24
Off-feed weight, lb.	900	1	901	5	898	7	894	3	880	12
Slaughter weight, lb.	837	4	856	8	853	9	835	6	822	10
Chilled carcass weight, lb.	534.1	5.1	533.0	8.4	537.8	11.2	533	2	485.8	5.4
Carcass grade[a]	12.8	0.3	11.4	0.7	10.2	0.5	9.0	0.5	10.8	0.2
Fat thickness, in.	0.63	0.06	0.66	0.06	0.27	0.04	0.30	0.05	0.22	0.01
Carcass length, in.	43.0	0.2	43.9	0.5	46.7	0.4	44.7	0.2	46.3	0.4
Marbling score[b]	6.0	0.3	5.4	0.7	4.5	0.3	3.2	0.2	8.0	0.0
L. dorsi muscle										
Specific gravity	1.0615	0.0010	1.0596	0.0020	1.0678	0.0009	1.0685	0.0009	1.0567	0.0012
Moisture, %	71.52	0.24	73.04	0.95	73.56	0.33	74.34	0.28	67.50	0.98
Ether extract, %	5.21	0.39	5.52	1.12	3.19	0.31	3.00	0.31	9.13	1.06
Protein, %	21.03	0.12	20.45	0.24	21.31	0.24	21.48	0.26	22.37	0.54
9-10-11 Rib section										
Moisture, %	41.66	0.92	43.67	1.58	53.03	1.51	48.86	1.49	45.40	1.99
Ether extract, %	44.16	0.96	43.29	2.11	30.22	1.93	34.96	1.82	42.02	1.50
Protein, %	12.74	0.26	12.54	0.54	15.43	0.43	14.84	0.42	12.08	0.91
Warner-Bratzler shear score, lb.										
Rib roast[c]	16.3	1.3	15.0	1.4	15.9	1.1	18.3	0.9	13.0	0.6
Loin steak[d]	5.6	0.2	5.3	0.2	5.7	0.2	7.5	0.8	4.8	0.3
Round steak[d]	9.2	0.5	9.1	0.7	10.2	0.6	9.0	0.3	8.0	0.7
Sensory panel score[e]										
Tenderness										
Rib roast	7.9	0.2	7.8	0.4	7.6	0.3	6.3	0.3	8.0	0.2
Loin steak	7.7	0.2	7.5	0.3	7.6	0.2	6.3	0.5	8.4	0.2
Round steak	5.9	0.4	5.6	0.5	5.3	0.2	5.4	0.2	6.6	0.4
Juiciness										
Rib roast	7.7	0.2	7.7	0.2	7.8	0.1	6.9	0.3	8.0	0.2
Loin steak	7.5	0.1	7.5	0.2	7.6	0.1	7.0	0.2	8.0	0.1
Round steak	6.6	0.2	6.7	0.2	6.6	0.1	6.4	0.3	6.8	0.6
Flavor										
Rib roast	7.4	0.2	7.2	0.1	7.4	0.2	7.0	0.1	7.7	0.6
Loin steak	7.4	0.1	7.2	0.1	7.4	0.1	6.8	0.2	7.4	0.1
Round steak	7.0	0.2	6.9	0.3	7.1	0.1	6.5	0.2	7.1	0.1

[a] 9 = Low Good, 10 = Average Good, 11 = High Good, 12 = Low Choice.
[b] 3 = Traces, 4 = Slight, 5 = Small, 6 = Modest, 8 = Slightly Abundant.
[c] 1-inch core.
[d] ½-inch core.
[e] 8 = Very Good, 7 = Good, 6 = Fair Plus, 5 = Fair.

be discussed because Cole *et al.* (1963, 1964a, and 1964b) have reported results of a larger type and breed study which included these steers.

MUSCLE FIBER DIAMETER

L. dorsi. Table 3 contains least squares means for muscle

Table 3. Least squares means for the effect of breed on muscle fiber diameter and percent wavy muscle fibers

Trait	Breed				
	Angus	Hereford	Charolais	Brahman	Jersey
Muscle fiber diameter, μ					
L. dorsi					
At slaughter	62.2[a]	65.6[a,b]	63.6[a,b]	68.0[b]	55.9
After chilling	56.1[a]	50.2	62.9[b]	63.3[b]	53.8[a]
Semimembranosus	55.2[a,b]	54.5[a]	60.7[b,c]	64.4[c]	55.6[a,b]
Percent wavy muscle fibers					
L. dorsi					
At slaughter	38.5[a]	53.3[a]	40.8[a]	35.1[a]	17.6[a]
After chilling	24.1[a]	35.9[a]	16.1[a]	23.9[a]	15.3[a]
Semimembranosus	20.1[a]	20.9[a]	16.8[a]	11.5[a]	7.3[a]

[a,b,c] Means on a line with the same superscripts are not significantly different. All others differ significantly ($P<.05$).

fiber diameter. Angus, Hereford, and Charolais did not differ significantly in fiber diameter of *l. dorsi* samples taken immediately after bleeding on the slaughter floor. Brahman steers had the largest fiber diameter (68.0μ) but did not differ significantly from Hereford and Charolais. The Jerseys had significantly smaller fibers (55.9μ) than the other breeds.

The *l. dorsi* samples taken from the 12th rib section after being chilled 48 hours showed a different fiber diameter pattern. The Hereford steers had significantly smaller fiber diameters (50.2μ) than other breeds. Angus (56.1μ) and Jersey steers (53.8μ) did not differ significantly but had smaller fibers ($P<.05$) than Charolais (62.9μ) or Brahman (63.3μ).

It was thought that the *l. dorsi* sample taken during slaughter would approximate a biopsy and possibly give results comparable to those from samples of the chilled carcass. However, the average fiber diameter for the samples taken at slaughter was greater in all breeds than for the chilled carcass samples. Part of this difference probably is due to difference in sample locations. The location of the sample taken at slaughter was over the 13th rib about 1 inch from the lateral muscle boundary. However, the sample from the chilled carcass was taken over the 12th rib near the center of the muscle. Thus, the chilled carcass sample was taken about 1½ inches anterior and 1 inch lateral to the sample taken during slaughter. Regardless of the location difference between samples, they were taken in as nearly the same location from animal to animal as possible.

Tuma *et al.* (1962) and Swanson *et al.* (1965) found that the *l. dorsi* differed in fiber diameter from end to end and side to side. The 12th rib area contained the smallest fibers and the lateral region had smaller fibers than the dorsal or middle regions.

Another possible reason for the difference in fiber diameter was the difference in treatment of the two samples. The *l. dorsi* sample taken during slaughter was chilled immediately after removal from the warm animal body. However, the sample taken after chilling for 48 hours was left attached to the body during this period. Therefore, the chilling process was much slower. This differential cooling rate probably affected the time course of rigor mortis.

Herring *et al.* (1965) found that the fiber diameter of *psoas major* muscle increased about 30% when tension on the muscle was released. Tension was released by positioning the carcass immediately postmortem in a horizontal, rather than hanging, position. Removing the sample during slaughter in the present study likewise would have had the effect of releasing tension and could account for the differences found in the two samples.

Semimembranosus. Fewer significant breed differences existed in fiber diameter of the *semimembranosus* than of the *l. dorsi.* The range in breed means also was less. The Angus, Hereford, and Jersey steers had the smaller average fiber diameters and did not differ significantly from one another. The Brahman had the largest fibers but did not differ significantly from the Charolais. Average fiber diameter was similar in the *l. dorsi* and *semimembranosus* samples.

Comparison of fiber diameters with means of measures of tenderness by breeds showed that a similar pattern existed.

Those breeds with the smaller fiber diameters, such as Angus, Hereford, and Jersey, tended to have more tender cooked muscle. This pattern existed in both Warner-Bratzler shear scores and sensory panel tenderness scores (Table 2).

WAVY MUSCLE FIBERS

The percent of wavy (kinked or crinkled) fibers was determined in each sample (Table 3). This characteristic was most pronounced in the *l. dorsi* sample taken during slaughter and least pronounced in the *semimembranosus*. Although breed differences were great and means had a range of as much as 35%, these differences were not statistically significant because of the large amount of variation within the breeds.

The *l. dorsi* sample taken during slaughter had decidedly different characteristics from the other two samples. It was much more difficult to tease into individual fibers and to measure for fiber diameter. It was nearly impossible to break apart some samples without excessive cutting of fibers. Cross striations were much less prominent than longitudinal striations. The percentage of wavy fibers was as high as 85 in some samples. These results support the work of Paul *et al.* (1944).

Relationships Between Traits

Simple correlation coefficients were calculated on a within-breed basis between selected production and carcass traits.

Muscle Fiber Diameter. As shown in Table 4, the associations between fiber diameters of the three muscle samples were low (r = 0.16 to 0.29). This indicated that the fiber diameter in one location was not a good predictor of the fiber diameter in another location.

Fiber diameter of the *l. dorsi* sample taken during slaughter was significantly correlated only with sensory panel tenderness scores of the 6th and 7th rib roast (r = 0.39) and juiciness of the *semimembranosus* muscle of the round steak (r = -.36). The relationship with flavor score of the loin steak (r = -.34) approached significance at the 5% level.

The heavier steers within the breeds tended to have larger fiber diameters in the *l. dorsi* samples taken after the carcasses were chilled. The negative association between fiber diameter

Table 4. Simple correlation coefficients[a] between selected traits and muscle fiber diameters

Trait	Source of muscle fibers: L. dorsi, At slaughter	L. dorsi, After chilling	Semimembranosus
Muscle fiber diameter			
L. dorsi			
At slaughter	—	0.16	0.16
After chilling	—	—	0.29
Days on feed	-.01	-.05	0.09
Average daily gain	0.23	0.06	0.02
Age at slaughter	-.29	0.03	0.01
Off-feed weight	0.09	0.24	0.00
Slaughter weight	0.13	0.28	0.16
Chilled carcass weight	0.06	0.17	0.12
Fat thickness	-.02	0.19	0.02
Carcass length	-.10	-.11	-.28
Marbling score	0.14	-.35	-.17
L. dorsi			
Specific gravity	-.01	0.00	0.08
Moisture	-.20	0.24	-.02
Ether extract	0.28	-.37*	0.10
Protein	-.03	0.38*	-.05
9-10-11 Rib section			
Moisture	-.18	0.15	-.07
Ether extract	0.14	-.09	0.03
Protein	0.06	-.03	0.13
Warner-Bratzler shear score			
Rib roast	-.22	0.25	-.04
Loin steak	0.29	0.49**	-.24
Round steak	-.01	-.01	-.07
Sensory panel score			
Tenderness			
Rib roast	0.39*	-.04	0.29
Loin steak	-.05	-.37*	0.05
Round steak	-.11	-.11	0.10
Juiciness			
Rib roast	0.13	0.10	0.41*
Loin steak	0.01	-.40*	0.12
Round steak	-.36*	0.11	-.03
Flavor			
Rib roast	-.06	-.08	0.02
Loin steak	-.34	-.03	-.06
Round steak	-.08	0.08	0.10

[a] Calculated on a within-breed basis.

*P < .05.
**P < .01.

and marbling score indicated that the larger fibers tended to be found in muscles with less marbling. Larger fibers were accompanied by more moisture ($r = 0.24$), less ether extract ($r = -.37$), and more protein ($r = 0.38$) in the *l. dorsi* muscle of the 9-10-11 rib section. The latter two correlation coefficients were significant at the 5% level. These results support the relationship found between fiber size and marbling score because a larger amount of intramuscular fat would tend to reduce the percent moisture and protein and increase the percent ether extract.

Fiber diameter of the chilled *l. dorsi* sample had a very low association with composition of the 9-10-11 rib section, found by Hankins and Howe (1946) to be a good predictor of carcass composition. Thus, carcass composition apparently had little, if any, influence on muscle fiber diameter in these data.

Fiber diameter of the chilled *l. dorsi* sample was significantly related to measures of tenderness and juiciness of the loin steaks, the cuts nearest, anatomically, to the sample location. Fiber diameter was positively related to Warner-Bratzler shear score ($r = 0.49$), and negatively related to sensory panel tenderness score ($r = -.37$) and juiciness score ($r = -.40$). This shows that larger fiber diameters were associated with less tender and less juicy meat. However, the relationships between fiber diameter of the chilled *l. dorsi* sample and measures of palatability of the *l. dorsi* in the 6th and 7th rib roast, or *semimembranosus* muscle of the round steak, were near zero. Thus, fiber diameter of the *l. dorsi* over the 12th rib probably would have little, if any, value in predicting palatability of other muscles or of other parts of the *l. dorsi*.

The proximity of the site of measurement of fiber diameter to the site of measurement of palatability apparently had little, if any, influence on their relationship when the *semimembranosus* was involved. The correlation coefficients between fiber diameter and measures of palatability of this muscle were near zero. The only statistically significant coefficient involving fiber diameter of the *semimembranosus* was with juiciness score of the rib roast. The value or meaning of this relationship is unknown.

Wavy Muscle Fibers. As shown in Table 5, the percent of wavy muscle fibers in the *l. dorsi* sample taken during slaughter was significantly related to several palatability measures. A greater percent of wavy fibers was associated with less tender, less juicy, and less flavorful loin and round steaks and rib roasts. However, none of these relationships were statistically significant when the *l. dorsi* sample from the chilled carcass was involved; but a greater percent of wavy fibers was significantly related to fiber diameter, length of time on feed, and average daily gain. Animals with a greater percent of wavy fibers tended to have smaller fibers ($r = -.36$), a shorter feeding period ($r = -.40$), and gain faster ($r = 0.36$). These relationships were much lower when the *l. dorsi* sample taken during slaughter and the *semimembranosus* sample were involved.

The percent of wavy fibers in the *semimembranosus* was negatively related to tenderness score ($r = -.29$), juiciness score ($r = -.39$), and flavor score ($r = -.23$) of the round steaks. These results show that an increase in percent of wavy fibers was associated with a decrease in juiciness, flavor, and tenderness as measured by the sensory panel. However, the relationship with shear score also was negative ($r = -.43$), which is not consistent with the panel tenderness score. These two measures of tenderness apparently were not measuring the same property in the round steaks. Their simple correlation coefficient was only 0.10.

Partial Correlation Coefficients Involving **L. Dorsi** Samples Taken After Chilling

Hiner *et al.* (1953) and Tuma *et al.* (1962) found that muscle fiber diameter increases accompanied animal age increases. However, in the present study this association was very low ($r = 0.03$). Holding off-feed weight constant changed the association little ($r_{12.3} = 0.06$). The variation in age was much less in this study than in the quoted studies and may be part of the reason for the low relationship between fiber diameter and age. However, Romans *et al.* (1965) found that fiber diameter did not vary consistently with maturity level.

Table 5. Simple correlation coefficients[a] between selected traits and percent wavy muscle fibers

Trait	Source of wavy muscle fibers		
	L. dorsi		
	At slaughter	After chilling	**Semimembranosus**
Percent wavy muscle fibers			
L. dorsi			
At slaughter	—	0.24	0.20
After chilling	—	—	0.10
Muscle fiber diameter			
L. dorsi			
At slaughter	-.01	-.10	0.15
After chilling	-.02	-.36*	-.21
Semimembranosus	-.21	-.11	-.14
Days on feed	0.01	-.40*	-.06
Average daily gain	0.07	0.36*	0.14
Age at slaughter	-.07	-.15	-.08
Off-feed weight	-.08	-.11	-.06
Slaughter weight	-.20	-.18	-.14
Chilled carcass weight	-.10	-.22	0.00
Fat thickness	0.02	-.25	0.10
Carcass length	0.20	-.09	-.24
Marbling score	0.04	0.13	-.10
L. dorsi muscle			
Specific gravity	0.03	0.12	-.10
Moisture	0.05	-.19	-.01
Ether extract	0.10	0.20	0.25
Protein	0.13	-.11	-.12
9-10-11 Rib section			
Moisture	0.10	-.07	-.21
Ether extract	-.08	0.08	0.27
Protein	0.11	0.04	-.21
Warner-Bratzler shear score			
Rib roast	0.28	-.02	0.27
Loin steak	0.50**	-.06	-.02
Round steak	-.02	0.07	-.43*
Sensory panel score			
Tenderness			
Rib roast	-.22	-.10	-.06
Loin steak	-.48**	0.21	0.06
Round steak	-.36*	0.22	-.29
Juiciness			
Rib roast	-.48**	-.12	-.24
Loin steak	-.06	-.14	0.14
Round steak	-.31	-.33	-.39*
Flavor			
Rib roast	-.41*	-.12	-.24
Loin steak	-.02	0.21	-.04
Round steak	-.44*	0.07	-.23

[a] Calculated on a within-breed basis.

*P < .05.
**P < .01.

Ramsey *et al.* (1967) reported that age of beef females significantly influenced muscle tenderness. The association between age and tenderness score ($r = -.32$) in the present study was changed little when fiber diameter was held constant ($r_{12.3} = -.35$), again indicating the independence of age and fiber diameter.

The relationship of fiber diameter to panel tenderness score ($r = -.37$) was lowered only slightly when percent of ether extract or marbling score of the *l. dorsi* was held constant ($r_{12.3} = -.34$ and $-.35$, respectively). The same relationship was not changed when animal age was held constant ($r_{12.3} = -.37$) and was increased slightly when off-feed weight was held constant ($r_{12.3} = -.39$). Thus, the relationship between fiber diameter and panel tenderness score appeared to be independent of fat content of the *l. dorsi,* animal age, and body weight.

The significant association of fiber diameter with panel juiciness score ($r = -.40$) was lowered when either percent of ether extract of the *l. dorsi* or marbling score was held constant ($r_{12.3} = -.31$ and $-.34$, respectively). The low relation of marbling score to panel tenderness score ($r = 0.12$) was reduced to zero when *l. dorsi* fiber diameter was held constant. The association of marbling score and juiciness score ($r = 0.29$) was approximately halved ($r_{12.3} = 0.17$) when fiber diameter was held constant. The simple correlation coefficient between marbling score and panel flavor score was only 0.12. Therefore, the amount of marbling in the *l. dorsi* muscle had little effect on muscle palatability measures.

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